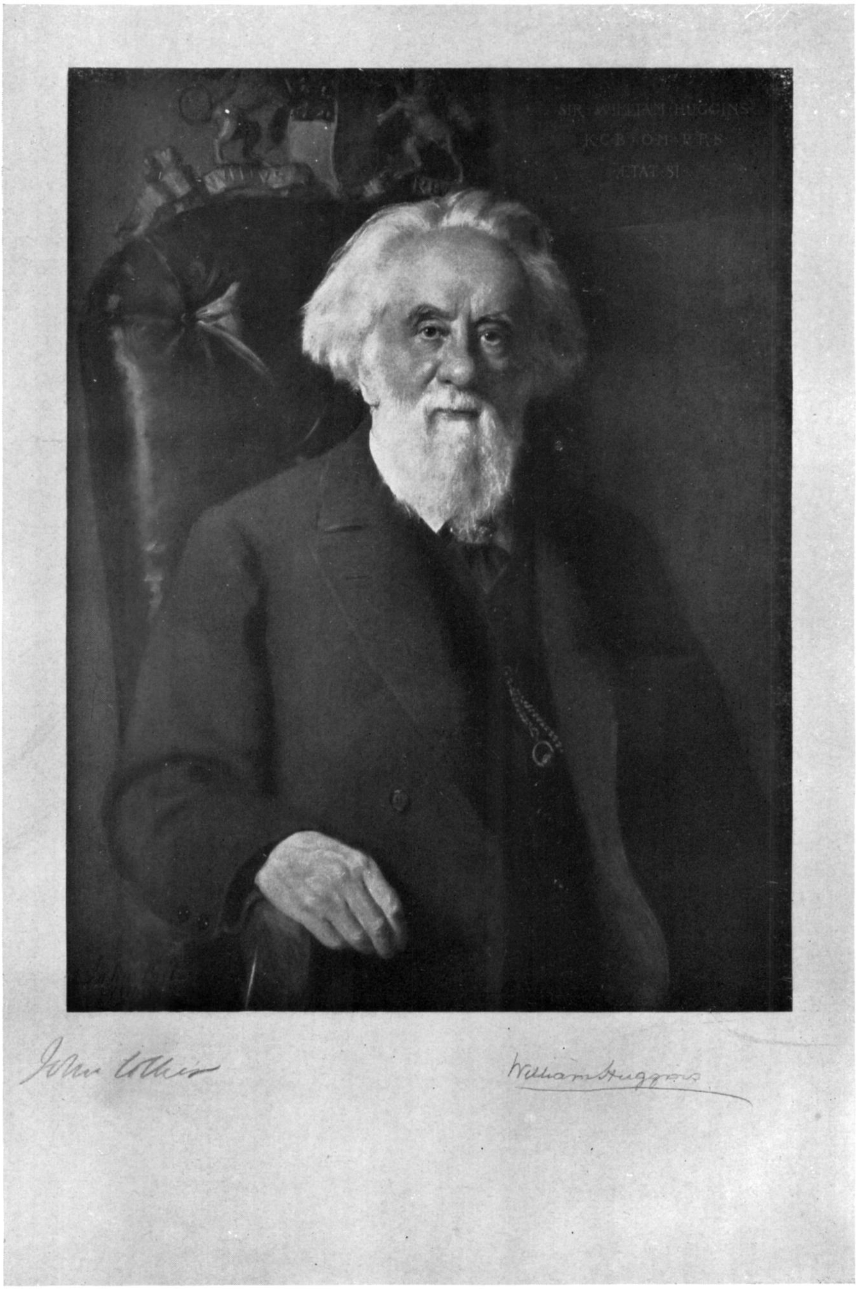

SIR WILLIAM HUGGINS.

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SIR WILLIAM HUGGINS, K. C. B., O. M.

BY W. W. CAMPBELL.

The name of Sir WILLIAM HUGGINS is intimately associated with the entire history of astronomical spectroscopy. With RUTHERFURD, SECCHI, ÅNGSTRÖM, DRAPER, and others, he was a pioneer in this subject; and by virtue of long life, enthusiasm, and uncommon wisdom, his contributions have enriched astronomical knowledge during a full half century. His lamented death on May 12, 1910, at the ripe age of eighty-six years, calls for a review of his remarkable career.

WILLIAM HUGGINS was born in London on February 7, 1824. His father was in commercial life, and was able to provide the son not only with a good education, but the financial means to follow astronomy in a private capacity, unattached to university or established observatory. His early education was received in the City of London School, and he later studied the languages, mathematics, and various branches of science extensively under private tutors. Astronomy and microscopy were subjects of special interest, and it was a difficult question with him as to which he should attempt to advance through original investigations. The decision was made in favor of astronomy. In 1856 he removed to 90 Upper Tulse Hill, then a short distance in the open country south of London, now within the great city, where he erected an observatory in connection with his dwelling-house; and there all of his work was done. "It consisted of a dome twelve feet in diameter and a transit-room. There was erected in it an equatorially mounted telescope by DOLLAND of five inches

aperture, at that time looked upon as a large rather than a small instrument." He commenced work on the usual lines, taking transits, observing, and making drawings of planets. In 1858 the 5-inch refractor was replaced by a Clark 8-inch refractor of great excellence.

In the *Nineteenth Century Review* for June, 1897, Sir WILLIAM has given an interesting account of his entry into the spectroscopic field:—

"I soon became a little dissatisfied with the routine character of ordinary astronomical work, and in a vague way sought about in my mind for the possibility of research upon the heavens in a new direction or by new methods. It was just at this time, when a vague longing after newer methods of observation for attacking many of the problems of the heavenly bodies filled my mind, that the news reached me of KIRCHHOFF's great discovery of the true nature and the chemical constitution of the Sun from his interpretation of the Fraunhofer lines.

"This news was to me like the coming upon a spring of water in a dry and thirsty land. Here at last presented itself the very order of work for which in an indefinite way I was looking,—namely, to extend his novel methods of research upon the Sun to the other heavenly bodies. A feeling as of inspiration seized me. I felt as if I had it now in my power to lift a veil which had never before been lifted; as if a key had been put into my hands which would unlock a door which had been regarded as forever closed to man—the veil and door behind which lay the unknown mystery of the true nature of the heavenly bodies. This was especially work for which I was to a great extent prepared, from being already familiar with the chief methods of chemical and physical research.

It was just at this time that I happened to meet at a soirée of the Pharmàceutical Society, where spectroscopes were shown my friend and neighbor, Dr. W. ALLEN MILLER, professor of chemistry at King's College, who had already worked much on chemical spectroscopy. A sudden impulse seized me to suggest to him that we should return home together. On our way home I told him of what was in my mind, and asked him to join me in the attempt I was about to make, to apply KIRCHHOFF's methods to the stars. At first, from consideration of the

great relative faintness of the stars, and the great delicacy of the work from the Earth's motion, even with the aid of a clock-work, he hesitated as to the probability of our success. Finally he agreed to come to my observatory on the first fine evening for some preliminary experiments as to what we might expect to do upon the stars.

" . . . From the Sun, with which the Heidelberg professors had to do,—which, even bright as it is, for some parts of the spectrum has no light to spare,—to the brightest stars is a very far cry. The light received at the Earth from a first magnitude star, as *Vega,* is only about the one-forty-thousand-millionth part of that received from the Sun.

"Fortunately, as the stars are too far off to show a true disk, it is possible to concentrate all the light received from the star upon a large mirror or object-glass, into the telescopic image, and so increase its brightness.

"We could not make use of the easy method adopted by FRAUNHOFER of placing a prism before the object-glass, for we needed a terrestrial spectrum, taken under the same conditions, for the interpretation, by a simultaneous comparison with it of the star's spectrum. KIRCHHOFF's method required that the image of a star should be thrown upon a narrow slit simultaneously with the light from a flame or from an electric spark.

"These conditions made it necessary to attach a spectroscope to the eye end of the telescope, so that it would be carried with it, with its slit in the focal plane. Then, by means of a small reflecting prism placed before one half of the slit, light from a terrestrial source at the side of the telescope could be sent into the instrument, together with the star's light, and so form a spectrum by the side of the stellar spectrum, for convenient comparison with it.

"This was not all. As the telescopic image of a star is a point, its spectrum will be a narrow line of light without appreciable breadth. Now for the observation either of dark or of bright lines across the spectrum a certain breadth is absolutely needful. To get breadth, the point-like image of the star must be broadened out.

"As light is of first importance, it was desirable to broaden the star's image only in the one direction necessary to give breadth to the spectrum; or, in other words, to convert the

stellar point into a short line of light. Such an enlargement in one direction only could be given by the device, first employed by FRAUNHOFER himself, of a lens convex or concave in one direction only, and flat, and so having no action on the light, in a direction at right angles to the former one. . . .

"It is scarcely possible at the present day, when all these points are as familiar as household words, for any astronomer to realize the large amount of time and labor which had to be devoted to the successful construction of the first star spectroscope. Especially was it difficult to provide for the satisfactory introduction of the light for the comparison spectrum. We soon found, to our dismay, how easily the comparison lines might become instrumentally shifted, and so be no longer strictly fiducial. As a test we used the solar lines as reflected to us from the Moon—a test of more than sufficient delicacy with the resolving power at our command.

"Then it was that an astronomical observatory began, for the first time, to take on the appearance of a laboratory. Primary batteries, giving forth noxious gases, were arranged outside one of the windows; a large induction coil stood mounted on a stand on wheels so as to follow the positions of the eye end of the telescope, together with a battery of several Leyden jars; shelves with Bunsen burners, vacuum tubes, and bottles of chemicals, especially of specimens of pure metals, lined its walls.

"In 1870 my observatory was enlarged from a dome of twelve feet in diameter to a drum having a diameter of eighteen feet. This alteration had been made for the reception of a larger telescope made by Sir HOWARD GRUBB, at the expense of a legacy to the Royal Society, and which was placed in my hands on loan by that society. This instrument was furnished with two telescopes: an achromatic of fifteen inches aperture and a Cassegrain of eighteen inches aperture, with mirrors of speculum metal. At this time one only of these telescopes could be in use at a time. Later on, in 1882, by a device which occurred to me of giving each telescope an independent declination axis, the one working within the other, both telescopes could remain together on the equatorial mounting, and be equally ready for use.

" . . . It is not easy for men of the present generation,

familiar with the knowledge which the new methods of research of which I am about to speak have revealed to us, to put themselves back a generation, into the position of the scientific thought which existed on these subjects in the early years of the Queen's reign. At that time any knowledge of the chemical nature and of the physics of the heavenly bodies was regarded as not only impossible of attainment by any method of direct observation, but as, indeed, lying altogether outside the limitations imposed upon man by his senses, and by the fixity of his position upon the Earth.

"It could never be, it was confidently thought, more than a matter of presumption, whether even the matter of the Sun, and much less that of the stars, were of the same nature as that of the Earth, and the unceasing energy radiated from it due to such matter at a high temperature. The nebular hypothesis of LAPLACE at the end of the last century required, indeed, that matter similar to that of the Earth should exist throughout the solar system; but then this hypothesis itself needed for its full confirmation the independent and direct observation that the solar matter was terrestrial in its nature. This theoretical probability in the case of the Sun vanished almost into thin air when the attempt was made to extend it to the stellar hosts; for it might well be urged that in those immensely distant regions an original difference of the primordial stuff as well as other conditions of condensation were present, giving rise to groups of substances which have but little analogy with those of our earthly chemistry. . . .

"The dark lines were described first by WOLLASTON in 1792, who strangely associated them with the boundaries of the spectral colors, and so turned contemporary thought away from the direction in which lay their true significance. It was left to FRAUNHOFER in 1815, by whose name the dark lines are still known, not only to map some six hundred of them, but also to discover similar lines, but differently arranged, in several stars. Further, he found that a pair of dark lines in the solar spectrum appeared to correspond in their position in the spectrum, and in their distance from each other, to a pair of bright lines which were nearly always present in terrestrial flames. This last observation contained the key to the interpretation of the dark lines as a code of symbols, but FRAUN-

HOFER failed to use it; and the birth of astrophysics was delayed. An observation by FORBES at the eclipse of 1836 led thought away from the suggestive experiments of FRAUNHOFER; so that in the very year of the Queen's accession the knowledge of the time had to be summed up by Mrs. SOMERVILLE in the negation: 'We are still ignorant of the cause of these rayless bands.'

"Later on, the revelation came more or less fully to many minds. FOUCAULT, BALFOUR STEWART, ÅNGSTRÖM prepared the way. Prophetic guesses were made by STOKES and by Lord KELVIN. But it was KIRCHHOFF who, in 1859, first fully developed the true significance of the dark lines; and by his joint work with Bunsen on the solar spectrum proved beyond all question that the dark lines in the spectrum of the Sun are produced by the absorption of the vapors of the same substances, which when suitably heated give out corresponding bright lines; and, further, that many of the solar absorbing vapors are those of substances found upon the Earth. The new astronomy was born.

"Soon after the close of 1862, in collaboration with Dr. W. A. MILLER, I sent a preliminary note to the Royal Society, 'On the Lines of Some of the Fixed Stars,' in which we gave diagrams of the spectra of *Sirius, Betelgeux,* and *Aldebaran,* with the statement that we had observed the spectra of some forty stars, and also the spectra of the planets *Jupiter* and *Mars*. It was a little remarkable that on the same day on which our paper was to be read, but some little time after it had been sent in, news arrived there from America that similar observations on some of the stars had been made by Mr. RUTHERFURD. A very little later similar work on the spectra of the stars was undertaken in Rome by SECCHI and in Germany by VOGEL.

"In February, 1863, the strictly astronomical character of the observatory was further encroached upon by the erection, in one corner, of a small photographic tent furnished with baths and other appliances for the wet collodion process. We obtained photographs, indeed, of the spectra of *Sirius* and *Capella;* but from want of steadiness and more perfect adjustment of the instruments, the spectra, though defined at the edges, did not show the dark lines as we expected. The

dry collodion plates then available were not rapid enough; and the wet process was so inconvenient for long exposures, from irregular drying, and draining back from the positions in which the plates had often to be put, that we did not persevere in our attempts to photograph the stellar spectra. I resumed them with success in 1875, as we shall see further on.

"Whenever the nights were fine, our work on the spectra of the stars went on, and the results were communicated to the Royal Society in April, 1864; after which Dr. MILLER had not sufficient leisure to continue working with me.

" . . . I pass on at once, therefore, to the year 1876, in which by the aid of the new dry plates, with gelatine films, introduced by Mr. KENNETT, I was able to take up again, and this time with success, the photography of the spectra of the stars, of my early attempts at which I have already spoken.

"By this time I had the great happiness of having secured an able and enthusiastic assistant by my marriage in 1875.

"The great and notable advances in astronomical methods and discoveries by means of photography, since 1875, are due almost entirely to the great advantages which the gelatine dry plate possesses for use in the observatory, over the process of DAGUERRE, and even over that of wet collodion. The silver-bromide gelatine plate, which I was the first, I believe, to use for photographing the spectra of stars, except for its grained texture, meets the need of the astronomer at all points. This plate possesses extreme sensitiveness; it is always ready for use; it can be placed in any position; it can be exposed for hours; lastly, immediate development is not necessary, and for this reason, as I soon found to be necessary in this climate, it can be exposed again to the same object on succeeding nights; and so make up by successive instalments, as the weather may permit, the total long exposure which may be needful.

"The power of the eye falls off as the spectrum extends beyond the blue, and soon fails altogether. There is therefore no drawback to the use of glass for the prisms and lenses of a visual spectroscope. But while the sensitiveness of a photographic plate is not similarly limited, glass, like the eye, is imperfectly transparent, and soon becomes opaque, to the parts of the spectrum at a short distance beyond the limit of the

visible spectrum. To obtain, therefore, upon the plate a spectrum complete at the blue end of stellar light, it was necessary to avoid glass, and to employ instead Iceland spar and rock crystal, which are transparent up to the limit of the ultra-violet light which can reach us through our atmosphere. Such a spectroscope was constructed and fixed with its slit at the focus of the great speculum of the Cassegrain telescope.

"How was the image of a star to be easily brought, and then kept, for an hour, or even for many hours, precisely at one place on a slit so narrow as about the one two-hundredth of an inch? For this purpose the very convenient device was adopted of making the slit-plates of highly polished metal, so as to form a divided mirror, in which the reflected image of a star could be observed from the eye end of the telescope by means of a small telescope fixed within the central hole of the great mirror. A photograph of the spectrum of α *Lyræ,* taken with this instrument, was shown at the Royal Society in 1876.

"In the spectra of such stars as *Sirius* and *Vega,* there came out in the ultra-violet region, which up to that time had remained unexplored, the completion of a grand rhythmical group of strong dark lines, of which the well-known hydrogen lines in the visible region form the lower members. Terrestrial chemistry became enriched with a more complete knowledge of the spectrum of hydrogen from the stars. Shortly afterwards, CORNU succeeded in photographing a similar spectrum in his laboratory from earthly hydrogen."

The years 1863 to 1890 were made fruitful by HUGGINS, especially in the comparison of terrestrial and stellar spectra. He established that the principal elements in the Earth's surface strata exist also in the atmospheres of the stars in the form of vapors and gases. Other studies attempted to arrange the principal stars in the order of their evolutionary history—in the order of their effective ages—from the different appearances of the hydrogen and metallic lines in their spectra.

HUGGINS's observation of the spectrum of a nebula, for the first time in 1864, has probably never been surpassed in dramatic interest in any department of science. From the days of Sir WILLIAM HERSCHEL it had been a much-discussed question whether the nebulæ—the faintly shining bodies which had not been resolved into separate star-images—were con-

tinuous in structure like a great gaseous cloud, or were composed of stars unresolvable on account of their enormous distances. To let HUGGINS speak:—

"The nature of these mysterious bodies was still an unread riddle. Towards the end of the last century the elder HERSCHEL, from his observations at Slough, came very near suggesting what is doubtless the true nature, and place in the cosmos, of the nebulæ. I will let him speak in his own words:—

"'A shining fluid of a nature unknown to us.

"'What a field of novelty is here opened to our conceptions! . . . We may now explain that very extensive nebulosity, expanded over more than sixty degrees of the heavens, about the constellation of *Orion;* a luminous matter accounting much better for it than clustering stars at a distance. . . .

"'If this matter is self-luminous, it seems more fit to produce a star by its condensation than to depend on the star for its existence.'

"This view of the nebulæ as parts of a fiery mist out of which the heavens had been slowly fashioned, began, a little before the middle of the present century, at least in many minds, to give way before the revelations of the giant telescopes which had come into use, and especially of the telescope, six feet in diameter, constructed by the late Earl of ROSSE at a cost of not less than £12,000.

"Nebula after nebula yielded, being resolved apparently into innumerable stars, as the optical power was increased; and so the opinion began to gain ground that all nebulæ may be capable of resolution into stars. According to this view, nebulæ would have to be regarded, not as early stages of an evolutional progress, but rather as stellar galaxies already formed, external to our system — cosmical 'sandheaps' — too remote to be separated into their component stars. Lord ROSSE himself was careful to point out that it would be unsafe from his observations to conclude that all nebulosity is but the glare of stars too remote to be resolved by our instruments. In 1858 HERBERT SPENCER showed clearly that, notwithstanding the Parsonstown revelations, the evidence from the observation of nebulæ up to that time was really in favor of their being early stages of an evolutional progression.

"On the evening of August 29, 1864, I directed my telescope for the first time to a planetary nebula in *Draco*. The reader

may now be able to picture to himself to some extent the feeling of excited suspense, mingled with a degree of awe, with which, after a few minutes of hesitation, I put my eye to the spectroscope. Was I not about to look into a secret place of creation?

"I looked into the spectroscope. No spectrum such as I expected! A single bright line only! At first I suspected some displacement of the prism, and that I was looking at a reflection of the illuminated slit from one of its faces. This thought was scarcely more than momentary. Then the true interpretation flashed upon me. The light of the nebula was monochromatic, and so, unlike any other light I had as yet subjected to prismatic examination, could not be extended out to form a complete spectrum. After passing through the two prisms it remained concentrated into a single bright line, having a width corresponding to the width of the slit, and occupying in the instrument a position at that part of the spectrum to which its light belongs in refrangibility. A little closer looking showed two other bright lines on the side towards the blue, all the three lines being separated by intervals relatively dark.

"The riddle of the nebulæ was solved. The answer, which had come to us in the light itself, read: Not an aggregation of stars, but a luminous gas. Stars after the order of our own Sun, and of the brighter stars, would give a different spectrum; the light of this nebula had clearly been emitted by a luminous gas. With an excess of caution, at the moment I did not venture to go further than to point out that we had here to do with bodies of an order quite different from that of the stars. Further observations soon convinced me that, though the short span of human life is far too minute relatively to cosmical events for us to expect to see in succession any distinct step in so august a process, the probability is indeed overwhelming in favor of an evolution in the past, and still going on, of the heavenly hosts. A time surely existed when the matter now condensed into the Sun and planets filled the whole space occupied by the solar system, in the condition of gas, which then appeared as a glowing nebula, after the order, it may be, of some now existing in the heavens. There remained no room for doubt that the nebulæ, which our telescopes revealed to us, are the early stages of long processions of

cosmical events, which correspond broadly to those required by the nebular hypothesis in one or other of its forms."

Further observations identified two of the lines as due to hydrogen. Observations by various spectroscopists have increased the number of bright lines known to exist in nebular spectra to thirty or forty, but aside from hydrogen and helium, accounting for about one half of all the observed lines, the constitution of the so-called gaseous nebulæ is unknown.

To leave the subject of the nebular spectrum here would mislead the inexperienced, and it is necessary to say that only a minority of the nebulæ thus far observed in this way show spectra consisting chiefly of bright lines. The spiral nebulæ have spectra chiefly continuous, and their composition and physical state remain a mystery. Even so for bright-line nebulæ, as observed by HUGGINS in 1864, we cannot say that they are shining by virtue of the heat of incandescence; the tendency of present-day opinion is that their substances are comparatively cool, and that their luminosity must arise from other conditions not now understood with certainty.

Important contributions to our knowledge of temporary stars—the so-called new stars—were made by HUGGINS in half a dozen papers on their spectra. The principal stars studied were those which appeared suddenly in *Corona Borealis,* in the Great Nebula in *Andromeda,* and in *Auriga.*

HUGGINS was among the first to apply the spectroscope to the study of comets. A dozen papers by him, on cometary spectra, make interesting reading, for they record the gradual evolution of our knowledge of physical conditions existing in comets up to the year 1882. For example, speaking of observations of Winnecke's Comet of 1868 made on the evening of June 22d, he says:—

"When a spectroscope furnished with two prisms of 60° was applied to the telescope, the light of the comet was resolved into three very broad, bright bands. . . .

"In the two more refrangible of these bands the light was brightest at the less refrangible end, and gradually diminished towards the other limit of the bands. This gradation of light was not uniform in the middle and brightest band, which continued of nearly equal brilliancy for about one-third of its

breadth from the less refrangible end. This band appeared to be commenced at its brightest side by a bright line.

"The least refrangible of the three bands did not exhibit a similar marked gradation of brightness. This band, though of nearly uniform brilliancy throughout, was perhaps brightest about the middle of its breadth. . . .

"The following day I carefully considered these observations of the comet with the hope of a possible identification of its spectrum with that of some terrestrial substance. The spectrum of the comet appeared to me to resemble some of the forms of the spectrum of carbon which I had observed and carefully measured in 1864. On comparing the spectrum of the comet with the diagrams of these spectra of carbon, I was much interested to perceive that the positions of the bands in the spectrum, as well as their general characters and relative brightness, agreed exactly with the spectrum of carbon when the spark is taken in olefiant gas. . . .

"It was with the spectrum of carbon, as thus obtained, that the spectrum of the comet appeared to agree. It seemed, therefore, to be of much importance that the spectrum of the spark in olefiant gas should be compared directly in the spectroscope with the spectrum of the comet. The comparison of the gas with the comet was made the same evening, June 23d. . . .

"The brightest end of the middle band of the cometic spectrum was seen to be coincident with the commencement of the corresponding band in the spectrum of the spark. As this limit of the band was well defined in both spectra, the coincidence could be satisfactorily observed up to the power of the spectroscope; and may be considered to be determined within about the distance which separates the components of the double line D. As the limits of the other bands were less distinctly seen, the same amount of certainty of exact coincidence could not be obtained. We considered these bands to agree precisely in position with the bands corresponding to them in the spectrum of the spark.

"The apparent identity of the spectrum of the comet with that of carbon rests not only on the coincidence of position in the spectrum of the bands, but also upon the very remarkable resemblance of the corresponding bands in their general characters and in their relative brightness. This is very noticeable

in the middle band, where the gradation of brightness is not uniform. This band in both spectra remained of nearly equal brightness for the same proportion of its length.

"On a subsequent evening, June 25th, I repeated these comparisons, when the former observations were fully confirmed in every particular. On this evening I compared the brightest band with that of carbon in the larger spectroscope, which gives a dispersion of about five prisms.

"The remarkably close resemblance of the spectrum of the comet to the spectrum of carbon necessarily suggests the identity of the substances by which in both cases the light was emitted."

The application of the Doppler-Fizeau principle to the measurement of stellar velocities has assumed great importance in astronomical investigation. It is now easy to look backward and say that this importance was inevitable, but it was not easy, half a century ago, to look forward and say that this must be so. It is characteristic of the pioneers in this field that they were slow to publish their ideas and observations.

It was FIZEAU, in 1848, who first enunciated the principle correctly that motions of approach and recession must cause corresponding shiftings of the entire spectrum, including the dark lines of FRAUNHOFER, toward the violet and red, respectively, but without change of color. He also outlined methods for applying the principle to measuring the motions of celestial bodies toward and away from the observer. While these methods were sound theoretically, they were unpractical. All matters spectroscopic were then mysterious, and FIZEAU'S statements attracted no serious attention. In fact, his lecture on the subject in 1848, before a minor society in Paris, was not published until 1869. The subject was given early consideration by HUGGINS and MILLER, but publication was delayed until 1868, when the following statement was issued:

"In a paper 'On the Spectra of Some of the Fixed Stars' by myself and Dr. W. A. MILLER, Treas. R. S., we gave an account of the method by which we had succeeded during the years 1862 and 1863 in making trustworthy simultaneous comparisons of the bright lines of terrestrial substances with the dark lines in the spectra of some of the fixed stars. We were at the time fully aware that these direct comparisons were not

only of value for the more immediate purpose for which they had been undertaken, namely, to obtain information of the chemical constitution of the investing atmospheres of the stars, but that they might also possibly serve to tell us something of the motions of the stars relatively to our system. If the stars were moving towards or from the Earth, their motion, compounded with the Earth's motion, would alter to an observer on the Earth the refrangibility of the light emitted by them, and consequently the lines of terrestrial substances would no longer coincide in position in the spectrum with the dark lines produced by the absorption of the vapors of the same substances existing in the stars."

Repeated efforts to measure the velocities of recession and approach of the stars were made in later years by HUGGINS and other observers; and while their results were inaccurate and erroneous, they did not work entirely in vain, for the successes of the later observers in any subject are built, to some extent, upon the failures of the pioneers. We now know that visual methods could not have had more than very moderate success, even under the most favorable conditions. The coming of very sensitive dry-plates has made it possible for a 6-inch telescope and spectrograph to measure the velocities of a greater number of stars than could be done with the 36-inch telescope, using visual methods of spectroscopy.

Perhaps HUGGINS's greatest contributions to the development of celestial spectroscopy have come from his efforts to interpret the original observations by means of laboratory observations made by himself and others. To these problems he brought philosophic judgment of unusual breadth and depth. His public addresses, reviewing astronomical progress and forecasting the problems of the future, were of unusual interest and excellence. The Cardiff address of 1891 was notable in this regard.

The epoch-making work of Huggins brought him early and full recognition from universities and learned societies. His government alone was slow to reward him. He was Rede Lecturer in Cambridge University in 1869; he received the degree of LL. D. from Cambridge in 1870, and the degree of D. C. L. from Oxford in 1870. He was made a member of the Royal Society in 1865. He received the Lalande Gold

Medal and the Janssen Gold Medal of the Paris Academy of Sciences; the Gold Medal of the Royal Astronomical Society; the Royal, the Rumford, and the Copley medals of the Royal Society; the Bruce Medal of the Astronomical Society of the Pacific; and perhaps others.

He received honorary degrees from many universities, and was elected to membership in the leading academies. He was president of the British Association in 1891, the year of the Cardiff meetings. He was president of the Royal Society during the years 1900-05. On the occasion of the Diamond Jubilee of Queen VICTORIA, in his seventy-fourth year, he was knighted; and in his seventy-eighth year he received appointment to the Order of Merit.

It is the way of Nature that ripeness must give way to youth. Fortunately, the example and work of such as HUGGINS live on into succeeding generations, and the history of astronomy will keep his name on the list of great pioneers.

For thirty-five years he experienced able and devoted support in his scientific duties and undertakings from Lady HUGGINS, whose assistance was always real and active. The history of science does not tell us of more devoted co-workers than Sir WILLIAM and Lady HUGGINS. The sympathies of all who have had the good fortune to know them go to her who has been left behind.